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$$\frac{ds}{dt} - a \frac{d\phi}{dt} = gt \cos \theta \frac{a^2 + k^2}{k^2} \left(\frac{k^2}{a^2 + k^2} \tan \theta - \mu \right) \dots (14).$$

By hypothesis, $\mu < \frac{k^2}{a^2 + k^2} \tan \theta$ or $< \frac{2}{7} \tan \theta$, and therefore $\frac{ds}{dt} - a \frac{d\phi}{dt}$ is positive, showing that all the motion is not rolling.

III. Solution by Professor P. H. PHILBRICK, M. S., C. E., Lake Charles, Louisiana.

Let a = the radius of the sphere, O the origin, A the point of the sphere in contact with the plane at O at starting and P the point in contact at the end of the time t . $OP = x$.

Let $ACP = \phi$, R = pressure on the plane, F = the sliding friction, and μ = coefficient of sliding friction = $\frac{F}{R}$.

Suppose the plane just rough enough to prevent sliding.

Then the equation for translation is $m \frac{d^2 x}{dt^2} = mg \sin \theta - F \dots (1)$,

and for rotation $mk_1^2 \frac{d^2 \phi}{dt^2} = aF \dots (2)$, in which k_1 = the radius of gyration and $\therefore k_1^2 = \frac{2}{5} a^2$.

Also $x = OP = \text{arc } AP = a\phi$; and differentiating twice gives, $\frac{d^2 x}{dt^2} = a \frac{d^2 \phi}{dt^2} \dots (3)$.

Multiply (1) by a and add to (2) and get, $ma \frac{d^2 x}{dt^2} + mk_1^2 \frac{d^2 \phi}{dt^2} = mg \sin \theta \dots (4)$.

Substituting from (3) we get, $\frac{d^2 \phi}{dt^2} = \frac{a}{a^2 + k_1^2} g \sin \theta$.

From (2) and (5), $F = \frac{mk_1^2}{a} \cdot \frac{d^2 \phi}{dt^2} = \frac{mk_1^2}{a} \cdot \frac{a}{a^2 + k_1^2} g \sin \theta = \frac{mk_1^2}{a^2 + k_1^2} g \sin \theta$.

Also $R = mg \cos \theta$. $\therefore \mu = \frac{F}{R} = \frac{k_1^2}{k_1^2 + a^2} \tan \theta = \frac{2}{7} \tan \theta$.

Hence if μ is less than $\frac{2}{7} \tan \theta$, it will all be utilized in causing rolling but it is insufficient to prevent some sliding.

DIOPHANTINE ANALYSIS.

Conducted by J. M. GOLAW, Monterey, Va. All contributions to this department should be sent to him.

SOLUTIONS TO PROBLEMS.

11. Proposed by ARTEMAS MARTIN, LL. D., U. S. Coast and Geodetic Survey Office, Washington, D. C.

Find three whole numbers such that the square of the sum of any two of them diminished by the square of the other number shall be a square.

Solution by the PROPOSER.

Let rx , ry , and rz represent the required numbers.
Then we must have

$$(rx+ry)^2-r^2z^2=\square=r^2a^2\dots(1),$$

$$(rx+rz)^2-r^2y^2=\square=r^2b^2\dots(2),$$

$$(ry+rz)^2-r^2x^2=\square=r^2c^2\dots(3).$$

Expunging the square factor r^2 we have

$$(x+y)^2-z^2=a^2\dots(4),$$

$$(x+z)^2-y^2=b^2\dots(5),$$

$$(y+z)^2-x^2=c^2\dots(6).$$

Adding (4), (5), and (6) we get

$$(x+y+z)^2=a^2+b^2+c^2, \text{ or } x+y+z=\sqrt{a^2+b^2+c^2}\dots(7),$$

and we must find $a^2+b^2+c^2=\square$.

From (4), (5), (6) and (7) we readily find

$$x=\frac{a^2+b^2}{2\sqrt{a^2+b^2+c^2}}, y=\frac{a^2+c^2}{2\sqrt{a^2+b^2+c^2}}, z=\frac{b^2+c^2}{2\sqrt{a^2+b^2+c^2}}.$$

If now we take $r=2\sqrt{a^2+b^2+c^2}$ we have

$$rx=a^2+b^2, ry=a^2+c^2, rz=b^2+c^2,$$

subject to the condition $a^2+b^2+c^2=\square$. The solution of this condition can be effected in many ways. See *Mathematical Magazine*, Vol. II., No. 5, pp. 71-74. Using the simple formula near the bottom of page 71, viz: and putting $a=p$, $b=p+1$, $c=p^2+p$, we have

$$a^2+b^2+c^2=p^2+(p+1)^2+(p^2+p)^2=(p^2+p+1)^2,$$

where p may have any integral value that will make the numbers all different. Take $p=2$, then $a=2$, $b=3$, $c=6$, $rx=13$, $ry=40$, $rz=45$, the numbers sought.

II. Solution by H. W. DRAUGHON, Clinton, Louisiana.

Put $(m^2+n^2)-y=1\text{st number}$, $y=2\text{nd number}$, and $m^2-n^2=3\text{rd number}$. Squaring the sum of the 1st and 2nd, and diminishing by the square of the 3rd, we have $(m^2+n^2)^2-(m^2-n^2)^2=4m^2n^2$, a square.

We have therefore only to make,

$$[(m^2+n^2-y)+m^2-n^2]^2-y^2=4m^2(m^2-y^2)=\square\dots(1), \text{ and}$$

$$(m^2-n^2+y)^2-(m^2+n^2-y)^2=4m^2(y-n^2)=\square\dots(2),$$

$$\text{in (1) make } m^2-y=p^2\dots(3) \text{ and in (2), make } y-n^2=q^2\dots(4).$$

From (3) and (4) we have, $n^2+q^2+p^2=m^2$.

This equation will be satisfied when, $n=(a^2+b^2-c^2)$, $q=2ac$, $p=2bc$, and $m=(a^2+b^2+c^2)$; a , b , and c can have any values that will not make any one of the required numbers greater than the sum of the other two.

Ex. Put $a=3$, $b=2$, and $c=1$, then $n=12$, $q=6$, $p=4$, and $m=14$.

From (3) or (4) we find $y=180$. Substituting these values in the original expressions, we have the following numbers, 180, 160, and 52. Dividing by 4, these numbers become 45, 40, and 13.

Also solved by C. W. M. BLACK, M. A. GRUBER, F. P. MATZ, J. F. W. SCHEFFER, and G. B. M. ZERR